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(54) **AIRCRAFT MANAGEMENT SYSTEM**

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B64F 5/40	(2017.01)
B64D 45/00	(2006.01)

(52) **U.S. Cl.**
CPC *B64F 5/60* (2017.01); *B64F 5/40* (2017.01); *G07C 5/006* (2013.01); *G07C 5/008* (2013.01); *B64D 2045/0085* (2013.01)

(58) **Field of Classification Search**
CPC ... B64F 5/60; B64F 5/40; G07C 5/006; G07C 5/008; B64D 2045/0085
See application file for complete search history.

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(57) **ABSTRACT**

An aircraft management system includes a sensor, a diagnosis executor, and an outputter. The sensor is loaded onto an aircraft. The diagnosis executor diagnoses health of a part of the aircraft on the basis of output from the sensor while the aircraft is flying. The outputter outputs predetermined recommendation information to an outside of the aircraft through wireless communication, in the case where the part satisfies a preset maintenance recommendation condition as a result of the diagnosis of the health.

19 Claims, 6 Drawing Sheets
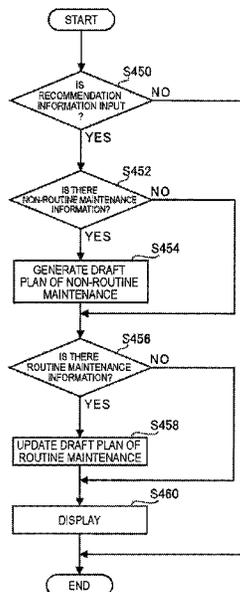
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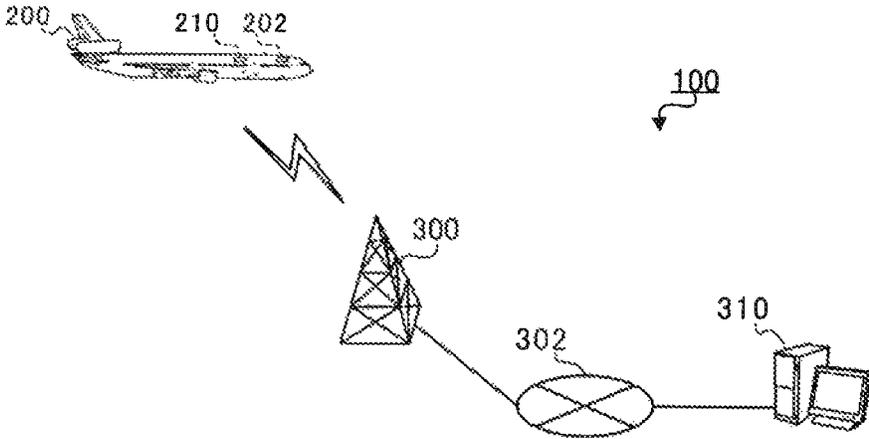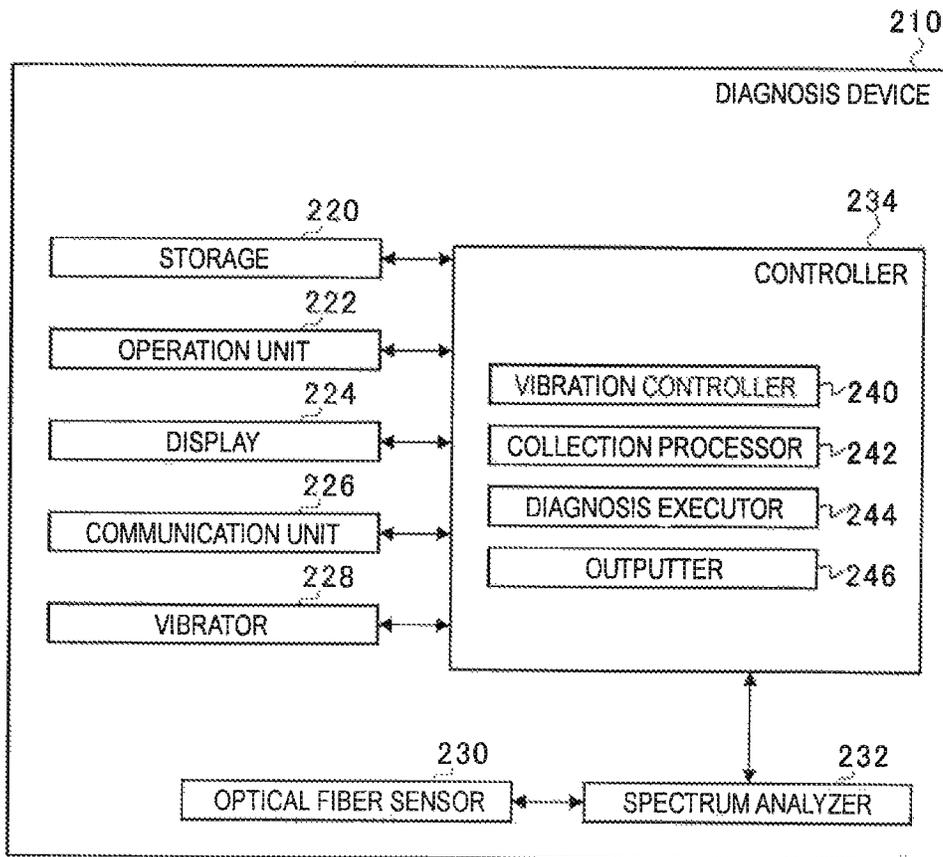
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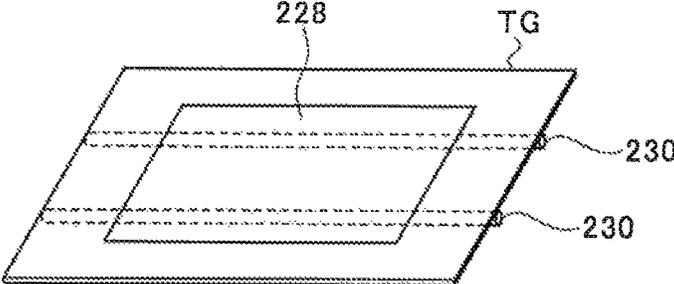
FIG. 1

FIG. 2

FIG. 3A

FIG. 3B

FIG. 4

310

MAINTENANCE MANAGEMENT SERVER

328

CONTROLLER

320
STORAGE

322
OPERATION UNIT

324
DISPLAY

326
COMMUNICATION UNIT

COMMUNICATION CONTROLLER ~340

PLANNER ~342

DISPLAY CONTROLLER ~344

FIG. 5

```
            ┌─────────┐
            │  START  │
            └─────────┘
                 │
                 ▼                      S400
        ┌─────────────────────┐
        │  HEALTH DIAGNOSIS   │
        │      PROCESS        │
        └─────────────────────┘
                 │
                 ▼                 S402
              ╱───────────╲
             ╱     IS       ╲        NO
            ╱ NON-ROUTINE    ╲─────────────┐
            ╲  MAINTENANCE   ╱              │
             ╲  NECESSARY?  ╱               │
              ╲───────────╱                 │
                 │ YES                       │
                 ▼              S404         │
        ┌─────────────────────┐             │
        │ GENERATE NON-ROUTINE│             │
        │MAINTENANCE INFORMATION│           │
        └─────────────────────┘             │
                 │◄───────────────────────────┘
                 ▼                 S406
              ╱───────────╲
             ╱ IS ROUTINE   ╲        NO
            ╱  MAINTENANCE   ╲─────────────┐
            ╲  NECESSARY?   ╱               │
             ╲───────────╱                  │
                 │ YES                       │
                 ▼              S408         │
        ┌─────────────────────┐             │
        │  GENERATE ROUTINE   │             │
        │MAINTENANCE INFORMATION│           │
        └─────────────────────┘             │
                 │◄───────────────────────────┘
                 ▼                 S410
              ╱───────────╲
             ╱  IS THERE    ╲        NO
            ╱ RECOMMENDATION ╲────────────┐
            ╲  INFORMATION  ╱              │
             ╲     ?      ╱                │
              ╲─────────╱                  │
                 │ YES                      │
                 ▼              S412        │
        ┌─────────────────────┐            │
        │       OUTPUT        │            │
        └─────────────────────┘            │
                 │◄──────────────────────────┘
                 ▼
            ┌─────────┐
            │   END   │
            └─────────┘
```

FIG. 6

START

S450
IS RECOMMENDATION INFORMATION INPUT?

NO

YES

S452
IS THERE NON-ROUTINE MAINTENANCE INFORMATION?

NO

YES

S454
GENERATE DRAFT PLAN OF NON-ROUTINE MAINTENANCE

S456
IS THERE ROUTINE MAINTENANCE INFORMATION?

NO

YES

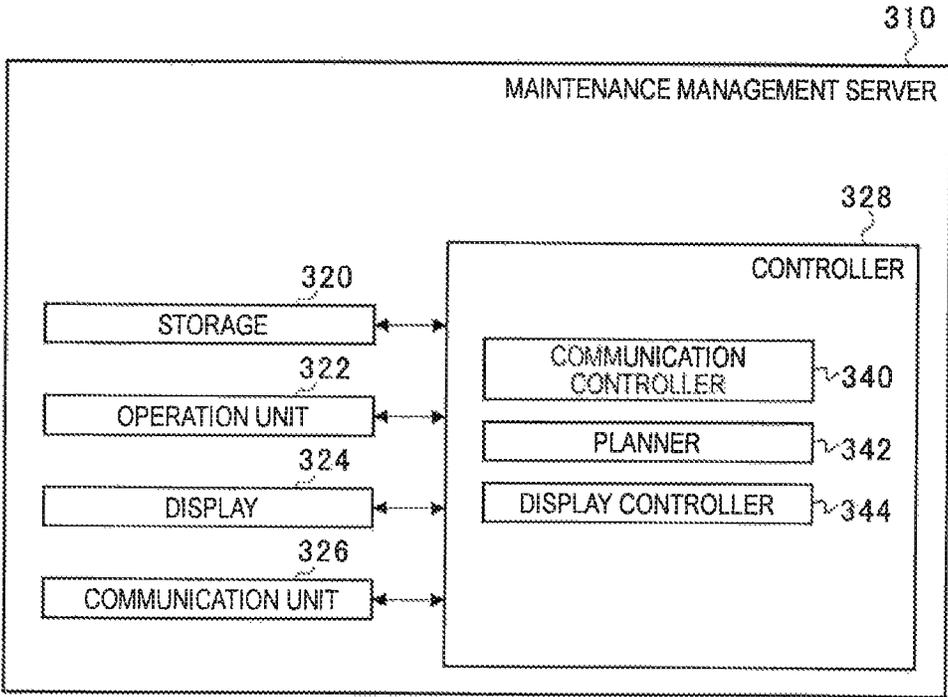S458
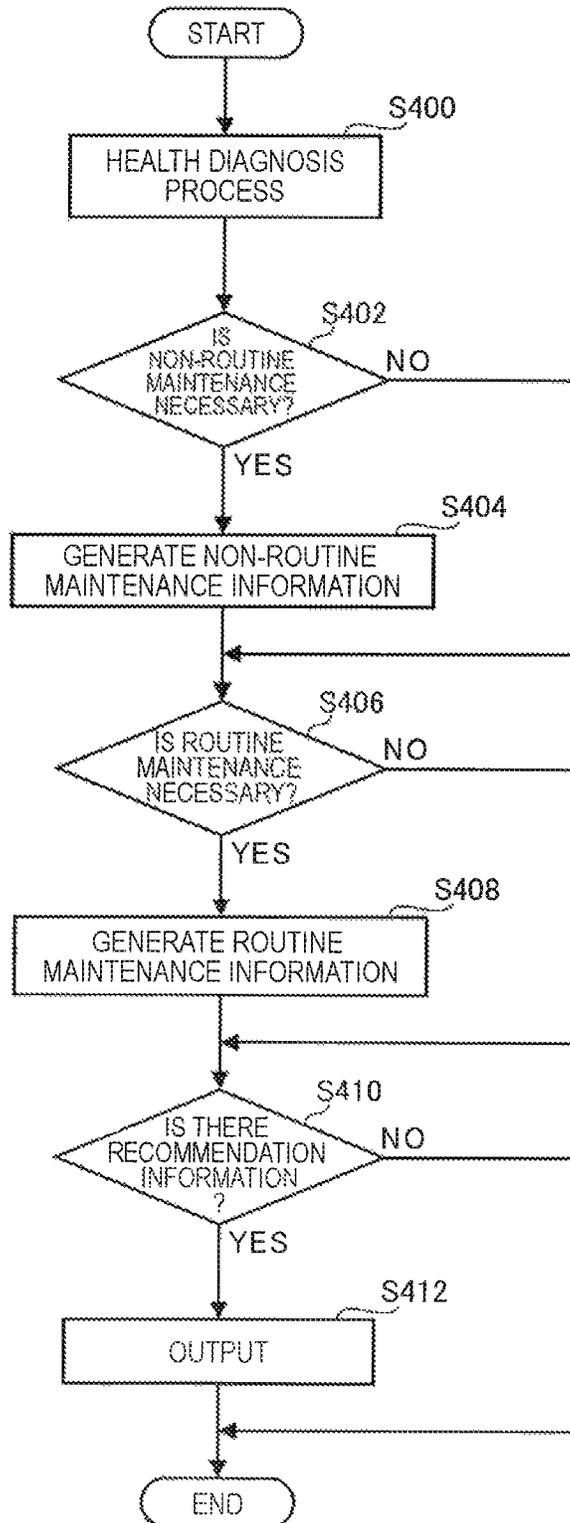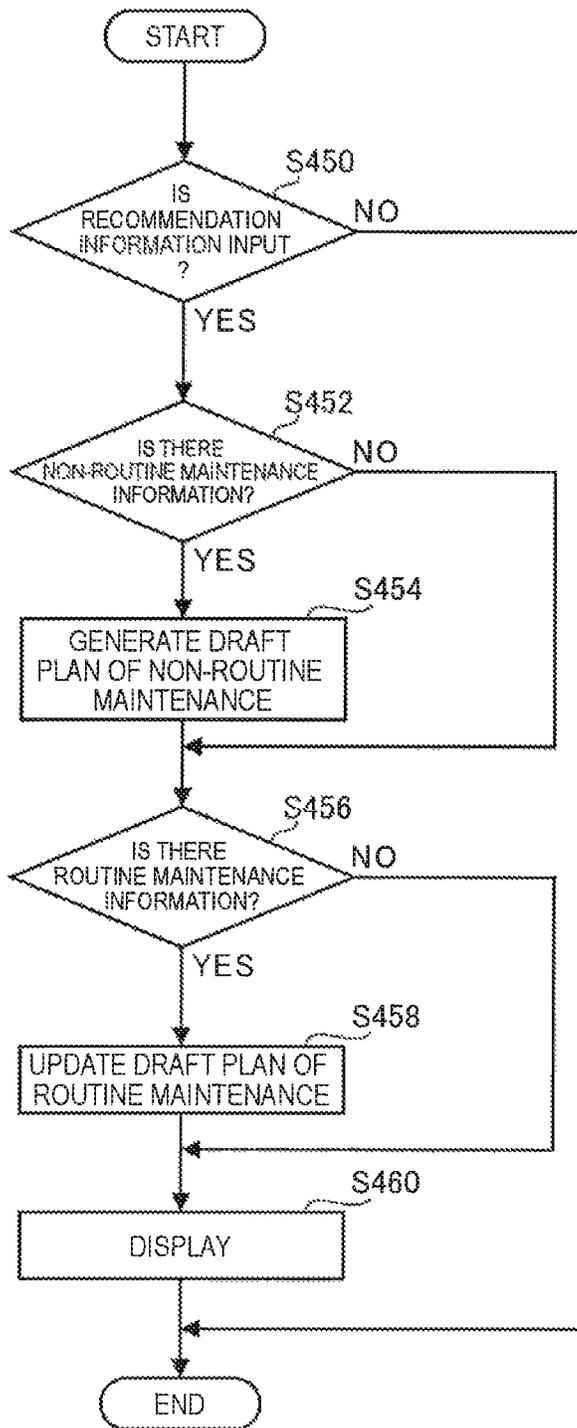UPDATE DRAFT PLAN OF ROUTINE MAINTENANCE

S460
DISPLAY

END

AIRCRAFT MANAGEMENT SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from Japanese Patent Application No. 2018-074548 filed on Apr. 9, 2018, the entire contents of which are hereby incorporated by reference.

BACKGROUND

The disclosure relates to an aircraft system.

An aircraft is inspected and maintained while being at an airport. Maintenance of the aircraft includes routine maintenance and non-routine maintenance. The routine maintenance is periodical maintenance that has been set in advance. In the routine maintenance, a maintenance item is decided in accordance with an upper limit of a maintenance interval that is set for each part included in the aircraft. In the non-routine maintenance, a cause of sudden malfunction is investigated and the cause is handled.

For instance, Japanese Unexamined Patent Application Publication (JP-A) No. 2013-14151 discloses a technology of accumulating measurement data in a data logger loaded onto an aircraft, the measurement data being obtained by various kinds of sensors while the aircraft is flying. After the aircraft lands, a server reads the measurement data accumulated in the data logger, and a maintenance item of routine maintenance is added in accordance with an analysis result of the measurement data.

SUMMARY

An aspect of the disclosure provides an aircraft management system including a sensor configured to be loaded onto an aircraft, a diagnosis executor configured to diagnose health of a part of the aircraft on the basis of output from the sensor while the aircraft is flying, and an outputter configured to output predetermined recommendation information to an outside of the aircraft through wireless communication, in the case where the part satisfies a preset maintenance recommendation condition as a result of the diagnosis of the health.

An aspect of the disclosure an aircraft management system including a sensor configured to be loaded onto an aircraft; and circuitry configured to diagnose health of a part of the aircraft on a basis of output from the sensor while the aircraft is flying and output a predetermined recommendation information to an outside of the aircraft through wireless communication, in a case where the part satisfies a preset maintenance recommendation condition as a result of diagnosis of the health.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification. The drawings illustrate example implementations and, together with the specification, serve to explain the principles of the disclosure.

FIG. 1 is a diagram illustrating an aircraft management system;

FIG. 2 is a block diagram illustrating a configuration of a diagnosis device;

FIG. 3 is an explanatory diagram of a vibrator and optical fiber sensors;

FIG. 4 is a block diagram illustrating a configuration of a maintenance management server;

FIG. 5 is a flowchart illustrating procedure of a process of the diagnosis device; and

FIG. 6 is a flowchart illustrating procedure of a process of the maintenance management server.

DETAILED DESCRIPTION

In the following, a preferred but non-limiting embodiment of the disclosure is described in detail with reference to the accompanying drawings. Note that sizes, materials, specific values, and any other factors illustrated in the embodiment are illustrative for easier understanding of the disclosure, and are not intended to limit the scope of the disclosure unless otherwise specifically stated. Further, elements in the following example embodiment which are not recited in a most-generic independent claim of the disclosure are optional and may be provided on an as-needed basis. Throughout the present specification and the drawings, elements having substantially the same function and configuration are denoted with the same reference numerals to avoid any redundant description. Further, elements that are not directly related to the disclosure are unillustrated in the drawings. The drawings are schematic and are not intended to be drawn to scale. As described in JP-A No. 2013-14151 referred to above, when a maintenance item of routine maintenance is added in accordance with an analysis result of measurement data, it is possible to give a reaction such as part replacement before malfunction occurs. Therefore, it is possible to suppress frequency of non-routine maintenance. However, since the maintenance item is added at the last minute, it is difficult to predict time it takes to perform routine maintenance until just before it happens.

It is desirable to provide the aircraft management system that makes it possible to suppress frequency of non-routine maintenance and early predict time it takes to perform routine maintenance.

FIG. 1 is a diagram illustrating an aircraft management system 100. As illustrated in FIG. 1, the aircraft management system 100 includes a diagnosis device 210 and a maintenance management server 310. The diagnosis device 210 is prepared for each of the aircrafts 200, and loaded onto each of the aircrafts 200. The maintenance management server 310 is prepared for each airport, for instance.

The diagnosis device 210 communicates with the maintenance management server 310 via a wireless communication device 202 loaded onto the aircraft 200, a base station 300, and a communication network 302 (Such as a LAN or the Internet). Hereinafter, the diagnosis device 210 will be described first, and then the maintenance management server 310 will be described next.

FIG. 2 is a block diagram illustrating a configuration of the diagnosis device 210. As illustrated in FIG. 2, the diagnosis device 210 includes a storage 220, an operation unit 222, a display 224, a communication unit 226, a vibrator 228, an optical fiber sensor 230 (sensor), a spectrum analyzer 232, and a controller 234.

The storage 220 is implemented as RAM, flash memory, an HDD, or the like. For instance, the operation unit 222 is implemented as a keyboard or a touchscreen that is superimposed on the display 224. The operation unit 222 receives operation input from a user. The display 224 is implemented as a liquid crystal display, an organic electro-luminescence (EL) display, or the like.

The communication unit **226** communicates with the wireless communication device **202** loaded onto the aircraft **200** in a wired manner, for instance. The vibrator **228** is implemented as piezoelectric elements (piezo elements) attached to a sheet.

FIG. **3** is an explanatory diagram illustrating the vibrator **228** and the optical fiber sensors **230**. FIG. **3A** illustrates a target TG to which the vibrator **228** and the optical fiber sensors **230** are attached. FIG. **3B** illustrates an internal configuration of the optical fiber sensor **230**.

For instance, the target TG is a part included in the aircraft **200**. The number of the targets TG is two or more, and the vibrator **228** and the optical fiber sensors **230** are prepared for each of the targets TG. Here, a case where the targets TG are plate-like members is taken as an instance. However, the shapes of the targets TG are not limited thereto. The vibrator **228** and the optical fiber sensors **230** are attached to (installed on) the target TG in an appropriate manner based on the shape of the target TG.

The piezoelectric elements of the vibrator **228** are coupled to conducting wire (not illustrated). When voltage is applied to a piezoelectric element via the conducting wire, the thickness of the piezoelectric element changes due to the piezoelectric effect. When pulse voltage is applied to any piezoelectric element among the piezoelectric elements, the vicinity of the piezoelectric element to which the voltage is applied gets vibrated in the target TG. In such a way, the vibrator **228** vibrates the target TG.

For instance, the optical fiber sensor **230** is intrinsic. In other words, in the optical fiber sensor **230**, the optical fiber itself functions as a sensor element. However, the optical fiber sensor **230** may be an extrinsic optical fiber sensor that causes the optical fiber to function only as an optical transmission line to/from another sensor element. For instance, the optical fiber sensor **230** is bonded to the target TG with adhesive.

As illustrated in FIG. **3B**, a core **230***a* is installed in the inside of a coating or cladding of the optical fiber sensor **230**. Light passes through the core **230***a*. Light transmitting through the core **230***a* toward an outside is reflected by the cladding and returned to the core **230***a*.

Grating members **230***b* are installed in the core **230***a*. The grating members **230***b* have different refractive indices from the other parts of the core **230***a*. The grating members **230***b* are installed apart from each other in the axis direction of the optical fiber. The grating members **230***b* cause the refractive indices to change periodically (fiber Bragg grating (FBG)).

In the grating members **230***b*, broadband spectrum light interferes with a specific wavelength called Bragg wavelength in a direction in which they strengthen each other. In such a way, the grating members **230***b* reflects only a specific wavelength component in the broadband spectrum light. Light of the other wavelength passes through the grating members **230***b*.

The wavelength of reflected light is changed when disturbance is added to the grating members **230***b*. The disturbance added to the grating members **203***b* is measured by measuring the change in the wavelength of the reflected light.

The spectrum analyzer **232** illustrated in FIG. **2** is coupled to the optical fiber sensors **230**. The spectrum analyzer **232** includes a light source and a light receiver. The light source emits broad spectrum light, and the broad spectrum light reaches the optical fiber sensors **230**. As described above, the optical fiber sensor **230** reflects a part of the light. The light receiver of the spectrum analyzer **232** receives the reflected light.

The spectrum analyzer **232** detects light intensity distribution in a predetermined wavelength band. The spectrum analyzer **232** detects the wavelength of the reflected light received by the light receiver. The wavelength detected by the spectrum analyzer **232** is converted from analog to digital by an A/D converter (not illustrated), and output to the controller **234**.

The controller **234** manages and controls the whole diagnosis device **210** by using a semiconductor integrated circuit including a central processing unit (CPU), ROM having a program or the like stored therein, RAM that functions as a work area, and the like. In addition, the controller **234** also functions as a vibration controller **240**, a collection processor **242**, a diagnosis executor **244**, and an outputter **246**.

The vibration controller **240** applies voltage to the vibrator **228** and causes the vibrator **228** to vibrate the target TG.

The collection processor **242** measures each of the targets TG by using the optical fiber sensors **230**. As described above, the collection processor **242** causes the spectrum analyzer **232** to emit the broad spectrum light and detect the wavelength of reflected light. The collection processor **242** uses the wavelength of the reflected light to measure change in the target TG that is a cause of the disturbance added to the grating members **230***b*.

For instance, with regard to the optical fiber sensor **230**, a physical quantity is set in advance. The physical quantity is a target of measurement such as distortion (stress) or temperature of the target TG. In other words, an optical fiber sensor **230** for measuring distortion, an optical fiber sensor **230** for measuring temperature, and the like are installed.

The collection processor **242** measures distortion of the target TG by using reflected light from the optical fiber sensor **230** for measuring distortion. In addition, the collection processor **242** measures temperature of the target TG by using reflected light from the optical fiber sensor **230** for measuring temperature.

In addition, the collection processor **242** may measure distortion of the target TG by using reflected light from the optical fiber sensor **230** for measuring distortion while the vibration controller **240** is controlling the vibrator **228** and the vibrator **228** is vibrating the target TG. If there is a deficient target TG between a piezoelectric element of the vibrator **228** and the optical fiber sensor **230**, different distortion (vibration) is measured in comparison with a case where there is no deficient target. In such a way, it is possible to detect the deficient target TG.

As described above, the collection processor **242** performs a correction process for collecting measurement data of the targets TG from the optical fiber sensors **230**.

The diagnosis executor **244** performs a health diagnosis process for diagnosing health of the targets TG of the aircraft **200** on the basis of the collected measurement data. The collection process and the health diagnosis process are performed at any timing while the aircraft **200** is flying.

In the health diagnosis process, the health of a structure is diagnosed by using the collected measurement data of the targets TG. For instance, the diagnosis executor **244** uses, as standard data, measurement data obtained when there is no distortion and no deficiency such as a timing immediately after the diagnosis device **210** is loaded onto the aircraft **200**. The diagnosis executor **244** derives evaluation values by comparing new measurement data with the standard data (by using differences, ratios, or the like between the new measurement data and the standard data). For instance, the health is calculated as a low evaluation value when the deficient target TG is detected or when the distortion or the temperature shows an abnormal value, as described above.

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As a result of the health diagnosis process, the diagnosis executor **244** determines whether inspection or maintenance of a part such as the target TG is necessary. Here, the part such the target TG includes any of the target TG itself and a part constituting a portion of the target TG.

For instance, when the evaluation value is less than a first threshold that is set in advance, the diagnosis executor **244** determines that a part such as the target TG has to be inspected or maintained as the non-routine maintenance. In the non-routine maintenance, a cause of sudden malfunction is investigated and the cause is handled. Therefore, in the case where it is determined that there is the part such as the target TG that has to go under the non-routine maintenance, the non-routine maintenance is performed at an airport where the aircraft **200** will arrive next.

In addition, when a preset maintenance recommendation condition is satisfied, the diagnosis executor **244** determines that a part has to be inspected or maintained as routine maintenance. Here, the maintenance recommendation condition is that the evaluation value is the first threshold or more and less than a second threshold, for instance. However, the maintenance recommendation condition may be optionally set such that it is possible to specify a part for which the non-routine maintenance is not necessary but inspection or maintenance is recommended.

The second threshold is set in advance, and is larger than the first threshold. Here, the routine maintenance is periodical maintenance that has been set in advance. Basically, in the routine maintenance, the maintenance item is decided in accordance with an upper limit of a maintenance interval that is set for each part such as the target TG. The inspection or maintenance of the part such as the target TG for which it is determined that the routine maintenance is necessary is added to maintenance items of next routine maintenance.

On the storage **220**, a type table is registered. In the type table, parts such as the targets TG constituting the aircraft **200** are associated with type information indicating types of the respective parts. The diagnosis executor **244** refers to the type table in the storage **220** and specifies the type information of a part for which inspection or maintenance is necessary.

When it is determined that inspection or maintenance is necessary for a part as a result of diagnosis of health performed by the diagnosis executor **244**, the outputter **246** controls the communication unit **226** and outputs recommendation information to an outside of the aircraft **200** through wireless communication. For instance, the outside of the aircraft **200** is the maintenance management server **310**. The recommendation information includes one or both of routine maintenance information and non-routine maintenance information.

The routine maintenance information includes the type information of a part for which inspection or maintenance is necessary as the routine maintenance (the part whose evaluation value is the first threshold or more and less than the second threshold) in the maintenance items of the next routine maintenance of the aircraft **200**. The routine maintenance information is for recommending including maintenance of that part.

The non-routine maintenance information includes the type information of a part for which inspection or maintenance is necessary as the non-routine maintenance (the part whose evaluation value is less than the first threshold). The non-routine maintenance information is for recommending performing the non-routine maintenance of the part whose evaluation value is less than the first threshold at an airport where the aircraft **200** will arrive next.

On the storage **220** of the diagnosis device **210**, addresses of airports where the aircraft **200** will arrive later in the communication network **302** are registered via the operation unit **222**. Therefore, it is possible for the outputter **246** to output recommendation information to the registered address.

In the case where the recommendation information includes the non-routine maintenance information, the outputter **246** outputs recommendation information to the maintenance management server **310** installed in an airport where the aircraft **200** will arrive next. Alternatively, in the case where the recommendation information includes the routine maintenance information, the outputter **246** outputs recommendation information to the maintenance management server **310** installed in an airport where next routine maintenance will be performed. Here, in the case where the airport where the next routine maintenance will be performed has not been decided yet (is not registered on the storage **220**), the outputter **246** outputs the recommendation information to the maintenance management server **310** of the airport where the next routine maintenance will be performed as soon as the airport where the next routine maintenance will be performed is decided.

Here, the case were the addresses of the airport were the aircraft **200** will arrive next and the airport where next routine maintenance will be performed in the communication network **302** are registered via the operation unit **222**, has been described above. However, it is also possible that an address table is registered on the storage **220** and the outputter **246** specifies an address on the basis of an input airport name and the address table. In the address table, names of airports are associated with addresses in the communication network **302**. In addition, the outputter **246** may acquire the address and the name of the airport from a controller (not illustrated) of the aircraft **200**.

FIG. **4** is a block diagram illustrating a configuration of the maintenance management server **310**. As illustrated in FIG. **4**, the maintenance management server **310** includes a storage **320**, an operation unit **322**, a display **324**, a communication unit **326**, and a controller **328**.

The storage **320** is implemented as RAM, flash memory, an HDD, or the like. For instance, the operation unit **322** is implemented as a keyboard or a touchscreen that is superimposed on the display **324**. The operation unit **322** receives operation input from a user. The display **324** is implemented as a liquid crystal display, an organic EL display, or the like. The communication unit **326** communicates with the diagnosis device **210** via the communication network **302**, the base station **300**, and the wireless communication device **202** of the aircraft **200**.

The controller **328** manages and controls the whole maintenance management server **310** by using a semiconductor integrated circuit including a central processing unit (CPU), ROM having a program or the like stored therein, RAM that functions as a work area, and the like. In addition, the controller **328** also functions as a communication controller **340**, a planner **342**, and a display controller **344**.

The communication controller **340** controls the communication unit **326** and acquires recommendation information output from the outputter **246** of the diagnosis device **210**. The planner **342** generates or changes a draft plan of maintenance when the recommendation information is input from the communication unit **326**.

On the storage **320**, a draft plan of maintenance of an aircraft **200** is registered, the aircraft **200** being at an airport where the maintenance management server **310** is installed. In the case where recommendation information includes

non-routine maintenance information, the planner **342** generates a draft plan of non-routine maintenance of the aircraft **200**. For instance, in this draft plan, a specific mechanism for the inspection or the maintenance and a predicted value of time it takes to perform the inspection or maintenance are set with regard to a part for which it is determined that non-routine maintenance is necessary.

In addition, on the storage **320**, a draft plan of routine maintenance of the aircraft **200** is registered in advance. As described above, with regard to the routine maintenance, maintenance items are decided in accordance with an upper limit of a maintenance interval that is set for each part such as the target TG. The frequency of routine maintenance, an airport where the routine maintenance will be performed, maintenance items of the routine maintenance are set such that each part such as the target TG does not exceed the upper limit of the maintenance interval.

In the case where recommendation information includes routine maintenance information, the planner **342** changes the draft plan of the routine maintenance of the aircraft **200** registered on the storage **320**. Specifically, the planner **342** adds maintenance of a part indicated by the routine maintenance information to the maintenance items of the draft plan of the routine maintenance registered on the storage **320**.

When a draft plan of non-routine maintenance is newly generated or a draft plan of routine maintenance is updated, the display controller **344** causes the display **324** to display the generated or updated draft plan. For instance, a worker resets allocation of mechanics or maintenance places in accordance with the displayed draft plan.

As described above, the aircraft management system **100** adds a maintenance item of routine maintenance in accordance with an evaluation value derived from the health diagnosis process. Therefore, it is possible to give a reaction such as part replacement before malfunction occurs, and suppress frequency of non-routine maintenance. In this case, a result of the health diagnosis process performed while the aircraft **200** has been flying is output to the maintenance management server **310** through wireless communication. Accordingly, it is possible to predict time it takes to perform routine maintenance before the aircraft **200** lands.

FIG. **5** is a flowchart illustrating procedure of a process of the diagnosis device **210**. The process illustrated in FIG. **5** is performed at any timing (for instance, is repeated on a predetermined cycle) while the aircraft **200** is flying.

(Step S400)

The diagnosis executor **244** performs the health diagnosis process for diagnosing health of a target TG of an aircraft **200** on the basis of measurement data collected by the collection processor **242**.

(Step S402)

As a result of the health diagnosis process, the diagnosis executor **244** determines whether the non-routine maintenance is necessary for the part such as the target TG. The process proceeds to Step S404 when it is determined that the non-routine maintenance is necessary (YES in Step S402). The process proceeds to Step S406 when it is determined that the non-routine maintenance is not necessary (NO in Step S402).

(Step S404)

The diagnosis executor **244** generates non-routine maintenance information including type information of the part for which it is determined that the non-routine maintenance is necessary.

(Step S406)

As a result of the health diagnosis process, the diagnosis executor **244** determines whether routine maintenance is necessary for the part such as the target TG. The process proceeds to Step S408 when it is determined that the routine maintenance is necessary (YES in Step S406). The process proceeds to Step S410 when it is determined that the routine maintenance is not necessary (NO in Step S406).

(Step S408)

The diagnosis executor **244** generates routine maintenance information including type information of the part for which it is determined that the routine maintenance is necessary.

(Step S410)

The diagnosis executor **244** determines whether recommendation information is generated, in other words, whether one or both of the routine maintenance information and the non-routine maintenance information are generated. The process proceeds to Step S412 in the case where the recommendation information is generated (YES in Step S410). The process ends in the case where the recommendation information is not generated (NO in Step S410).

(Step S412)

The outputter **246** controls the communication unit **226**, and outputs the recommendation information to an outside of the aircraft **200** through wireless communication. In the case where the recommendation information includes the non-routine maintenance information, the outputter **246** outputs the recommendation information to the maintenance management server **310** installed in an airport where the aircraft **200** will arrive next. In the case where the recommendation information includes the routine maintenance information, the outputter **246** outputs the recommendation information to the maintenance management server **310** installed in an airport where next routine maintenance will be performed.

FIG. **6** is a flowchart illustrating procedure of a process of the maintenance management server **310**. The process illustrated in FIG. **6** is repeated on a predetermined cycle, for instance.

(Step S450)

The planner **342** determines whether the recommendation information is input from the communication unit **326**. The process proceeds to Step S452 in the case where the recommendation information is input (YES in Step S450). The process ends in the case where the recommendation information is not input (NO in Step S450).

(Step S452)

The planner **342** determines whether the recommendation information includes the non-routine maintenance information. The process proceeds to step S454 in the case where the non-routine maintenance information is included (YES in Step S452). The process proceeds to Step S456 in the case where the non-routine maintenance information is not included (NO in Step S452).

(Step S454)

The planner **342** generates a draft plan of non-routine maintenance.

(Step S456)

The planner **342** determines whether the recommendation information includes the routine maintenance information. The process proceeds to Step S458 in the case where the routine maintenance information is included (YES in Step S456). The process proceeds to Step S460 in the case where the routine maintenance information is not included (NO in Step S456).

(Step S458)

The planner **342** updates the draft plan of the routine maintenance.

(Step S460)

When the draft plan of the non-routine maintenance is newly generated or the draft plan of the routine maintenance is updated, the display controller **344** causes the display **324** to display (announce) the generated or updated draft plan.

Although the embodiment of the disclosure has been described in detail with reference to the appended drawings, the disclosure is not limited thereto. It is obvious to those skilled in the art that various modifications or variations are possible insofar as they are within the technical scope of the appended claims or the equivalents thereof. It should be understood that such modifications or variations are also within the technical scope of the disclosure.

For instance, in the above-described embodiment, the vibrator **228** and the optical fiber sensors **230** have been used as instances. However, it is possible to use other sensors. The vibrator **228** is not an essential structural element. In addition, the fiber Bragg grating optical fiber sensors **230** have been used as instances. However, it is possible to use optical fiber sensors **230** of another type. It is possible to measure a physical quantity or a chemical quantity of a target TG by using not change in wavelength of light but change in other characteristics (intensity, phase, frequency, or polarized wave).

In addition, in the above-described embodiment, the case where the recommendation information is for recommending including maintenance of a part that satisfies the maintenance recommendation condition in the maintenance items of next routine maintenance of the aircraft **200**, has been described. In this case, it is possible to rapidly perform the maintenance of the part that satisfies the maintenance recommendation condition. However, the maintenance timing is not limited to the next routine maintenance. It is only necessary to include the maintenance of the part that satisfies the maintenance recommendation condition in maintenance items of any future routine maintenance. Simply, it is only necessary that the recommendation information be information capable of specifying a part estimated to need routine maintenance.

In addition, in the above-described embodiment, the case where the maintenance management server **310** is installed has been described. In this case, a draft plan of routine maintenance is certainly updated. However, the maintenance management server **310** is not an essential structural element. It is also possible to update the draft plan of routine maintenance in accordance with operation input by a worker.

It should be appreciated that modifications and alterations may be made by persons skilled in the art without departing from the scope as defined by the appended claims. The use of the terms first, second, etc. does not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. The technology is intended to include such modifications and alterations in so far as they fall within the scope of the appended claims or the equivalents thereof.

According to the embodiment of the disclosure, it is possible to suppress frequency of the non-routine maintenance and early predict time it takes to perform the routine maintenance.

The invention claimed is:

1. An aircraft management system comprising:

a sensor configured to be attached to an aircraft;

a diagnosis device that includes a controller having a diagnosis executor that is configured to diagnose health of a target part of the aircraft, while the aircraft is flying, inclusive of a diagnosis on a basis of output from the sensor, the controller being configured to output a dedicated target part test signal to a generator device that generates a characteristic change in the target part for testing purposes, which change in characteristic of the target part is sensed by the sensor; and

an outputter configured to output a predetermined recommendation information to an outside of the aircraft through wireless communication, in a case where the target part satisfies a preset maintenance recommendation condition as a result of the diagnosis of the health, and wherein the predetermined recommendation information includes one or both of routine maintenance information and non-routine maintenance information, and

wherein the diagnosis executor is configured to diagnose a first health condition indicative of a need for routine maintenance and a second health condition indicative of a need for non-routine maintenance, and wherein the outputter is configured to switch between the output of recommendation information as to the need for non-routine maintenance and the output of recommendation information as to the need for routine maintenance according to the result of the health diagnosis by the diagnosis executor, and

the aircraft management system further comprises a maintenance management server including a storage, an operation unit, a communication unit that is configured for communication with the outputter and a display, the storage includes a draft plan of routine maintenance of the aircraft, wherein maintenance items of the routine maintenance are decided in accordance with an upper limit of a maintenance interval that is set for each part of the aircraft stored in the aircraft management system.

2. The aircraft management system according to claim **1**, wherein, when the diagnosis executor diagnoses the second health condition, the recommendation information as to the need for non-routine maintenance includes recommending maintenance of the target part in a maintenance item established by the management server at an airport where the aircraft will land next.

3. The aircraft management system according to claim **1**, wherein

the maintenance management server, in generating the draft plan of the routine maintenance, when the recommendation information as to the need for routine maintenance is input, includes storing a maintenance item for routine maintenance performance for later forwarding to a next airport for the routine maintenance performance once registered in the management server.

4. The aircraft management system according to claim **1** wherein the generator device is a target part vibration generator device.

5. The aircraft management system according to claim **4** wherein the generator device is a piezo electric vibration generator device that is attached to the target part.

6. The aircraft management system according to claim **1** wherein the controller is configured to control output of the dedicated target part test signal and to provide pulse signals to the generator device so as to generate vibrations in the

target part to enable the change in characteristic in the target part which is sensed by the sensor.

7. The aircraft management system according to claim 1 wherein the dedicated target part test signal to the generator device generates the characteristic change in the target part solely for testing purposes.

8. The aircraft management system according to claim 1 further comprising a spectrum analyzer, and wherein the sensor comprises an optical fiber, and the spectrum analyzer is in communication with both the controller and the optical fiber.

9. The aircraft management system according to claim 1 wherein the sensor includes an adhesive for attachment to the aircraft.

10. The aircraft management system according to claim 1, wherein the maintenance management server is configured to include, in addition to the draft plan of the routine maintenance when routine maintenance recommendation information is received,

a draft plan of non-routine maintenance when non-routine maintenance recommendation information is received; and

wherein the maintenance management server is further configured to send the draft plan of the non-routine maintenance to an airport of next arrival for the aircraft, and send the draft plan of the routine maintenance to an airport where next routine maintenance is set to be performed.

11. The aircraft management system according to claim 1 wherein the diagnosis device sets a first target wear level threshold and a second target wear level threshold, and wherein, upon a wear level of the target part exceeding the first target wear level threshold and falling below the second target wear level threshold, the first health condition is set by the diagnosis executor and a routine maintenance plan is developed by the maintenance management server that takes into consideration the second target wear level threshold as the upper limit of the maintenance interval.

12. The aircraft management system according to claim 11 wherein the diagnosis device, upon detection of non-routine maintenance requirement prior to the wear level of the target part reaching the first target wear level threshold, sets the second health condition indicative of the need for non-routine maintenance.

13. The aircraft management system of claim 1 wherein the target part is a sheet of the aircraft.

14. An aircraft management system comprising:

a sensor configured to be loaded onto an aircraft and attached to a target part of the aircraft; and

circuitry configured to

diagnose health of the target part of the aircraft, while the aircraft is flying, inclusive of a diagnosis on a basis of output from the sensor, and

output a dedicated test initiation signal to a generator device that generates a change in characteristic in the target part for test purposes, which change in characteristic is sensed by the sensor;

diagnose a first health condition indicative of a need for routine maintenance and a second health condition indicative of a need for non-routine maintenance; and

output a predetermined recommendation information to an outside of the aircraft through wireless communication, in a case where the target part satisfies a preset maintenance recommendation condition as a

result of the diagnosis of the health, wherein the preset recommendation information includes one or both of routine maintenance information and non-routine maintenance information, and;

the aircraft management system further comprises a maintenance management server including a storage, an operation unit, a communication unit that is configured for communication with the circuitry for outputting the predetermined recommendation information and a display, the storage includes a draft plan of routine maintenance of the aircraft, wherein maintenance items of the routine maintenance are decided in accordance with an upper limit of a maintenance interval that is set for each part of the aircraft stored in the aircraft management system.

15. An aircraft management system comprising:

a sensor configured to be loaded onto an aircraft;

a diagnosis executor configured to diagnose health of a part of the aircraft inclusive of a diagnosis on a basis of an aircraft part characteristic change determination output from the sensor while the aircraft is flying;

a controller configured to initiate a test generation signal that results in the aircraft part characteristic change determination output from the sensor; and

an output device configured to output a predetermined recommendation information to an outside of the aircraft through wireless communication, in a case where the aircraft part satisfies a preset maintenance recommendation condition as a result of the diagnosis of the health, wherein the predetermined recommendation information includes one or both of routine maintenance information and non-routine maintenance information, and

wherein the diagnosis executor is configured to diagnose a first health condition indicative of a need for routine maintenance and a second health condition indicative of a need for non-routine maintenance, and wherein the aircraft management system further comprises a maintenance management server including a storage, an operation unit, a communication unit that is configured for communication with the output device and a display, the storage includes a draft plan of routine maintenance of the aircraft, wherein maintenance items of the routine maintenance are decided in accordance with an upper limit of a maintenance interval that is set for each part of the aircraft stored in the aircraft management system.

16. The aircraft management system of claim 15 wherein the sensor is an optical fiber sensor and the aircraft part characteristic change is a distortion stress change in the aircraft part.

17. The aircraft management system of claim 15 wherein the sensor is an optical fiber sensor that comprises a fiber Bragg grating.

18. The aircraft management system of claim 15 further comprising a vibration device attached to the aircraft part and wherein a target part distortion stress is generated in the aircraft part by the vibration device and the test generation signal causes a development of a vibration in the vibration device.

19. The aircraft management system of claim 15 further comprising a spectrum analyzer and wherein the sensor comprises an optical fiber that is in communication with the spectrum analyzer.

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